

DRAFT

Charge to Concentration, Forms and Ratios Science Work Group

Background

In 2009 the California legislature passed the Delta Reform Act creating the Delta Stewardship Council. The mission of the Council is to implement the coequal goals of the Reform Act and provide a more reliable water supply for California while protecting, restoring, and enhancing the Delta ecosystem. The Council wrote and adopted a Delta Plan in 2013 to implement these goals. Chapter 6 of the Delta Plan deals with water quality and contains recommendations to implement the coequal goals of the Delta Reform Act. Recommendation # 8 states, in part,

“...the State Water Resources Control Board and the San Francisco Bay and Central Valley Regional Water Quality Control Boards should prepare and begin implementation of a study plan for the development of objectives for nutrients in the Delta ... by January 1, 2014. Studies needed for development of Delta... nutrient objectives should be completed by January 1, 2016. The Water Boards should adopt and begin implementation of nutrient objectives, either narrative or numeric, where appropriate, in the Delta... by January 1, 2018.

Potential nutrient related problems identified in the Delta Plan for evaluation are:

1. Decreases in algal abundance and shifts in algal species composition, resulting in potential food web impacts
2. Increases in the abundance and distribution of macrophytes, including water hyacinth and brazilian waterweed,
3. Increases in the magnitude and frequency of cyanobacteria blooms

This charge addresses issue #1, assessing whether the observed decrease in algal abundance and shift in algal species composition in the Delta is the result of long term changes in nutrient concentrations and whether nutrient management might remedy the food web problem.

In the spring of 2014 Water Board staff wrote a new five-year Delta Strategic Work Plan to help prioritize Delta activities. The five-year plan was presented as an information item at the February 2014 Board meeting. Item five in the Strategic Plan lays out tasks, schedule and deliverables to begin implementing the nutrient recommendations in the Delta Plan (Figure 1). The Strategic Plan included the formation of a Technical Advisory Committee and a Stakeholder Advisory Group (which was later combined into the Stakeholder and Technical Advisory Group or STAG) to help respond to Delta Plan recommendations and to identify additional issues of

concern. The Water Board is also forming several Science Work Groups to help develop white papers on the three identified nutrient related problems. White papers may include recommendations for research to resolve outstanding questions about the efficacy of nutrient management to control the decrease in algal abundance and the shift in algal species composition. These recommendations will be incorporated into the Nutrient Research Plan. Draft white papers and a draft Nutrient Research Plan will be available for review by the STAG and the State Board's Independent Science Review Panel in 2015. A final Nutrient Research Plan addressing all review comments will be presented to the Central Valley Regional Water Board and, if requested, the Delta Stewardship Council in 2015.

The purpose of the Concentration, Forms and Ratios Science Work Group is to review existing studies and provide advice on whether sufficient information exists to conclude that long-term changes in nutrient loads, forms and ratios contribute to the observed decrease in algal abundance of desirable species and to shifts in algal species composition in the Delta. If the conclusions from this and the other science work groups, after development and fulfillment of the research plan, is that nutrients contribute to these effects and associated problems, then Water Board staff will begin the process of developing nutrient objectives.

Nutrient Hypotheses

It is requested that the Concentration, Forms and Ratios Work Group evaluate the relevance and support for various nutrient related food web hypotheses for the freshwater Delta. One hypothesis concerns the physiological effect of elevated concentrations of ammonia (NH₄) on phytoplankton biomass and community composition. This hypothesis is referred to as the "*Ammonia Paradox*" hypothesis after Dugdale *et al.*, 2012¹. The hypothesis is that elevated concentrations of NH₄ suppress nitrate (NO₃) uptake in some algal groups commonly present in the Delta leading to a reduction in total nitrogen (NH₄+NO₃) uptake. Decreases in nitrogen uptake result in a decrease in primary production rates and, if some algal functional groups are differentially sensitive to NH₄, to shifts in community composition from more to less sensitive algal forms (Table 1)

A second hypothesis concerns the effect of shifts in nitrogen to phosphorus (N:P) ratios on algal community composition and algal nutritional quality to herbivores. This hypothesis is called the *Ecological Stoichiometry* hypothesis after Glibert *et al.*, 2010² and is believed to occur even

¹ Dugdale, R, F. J. Wilson, A. Parker, A. Marchi, and K. Taberski. 2012. Estuarine, Coastal and Shelf Science, 115, 187-199.

² Glibert, P. (2010). Review of Fishery Science 18, 211-231.

when nutrient concentrations are in surplus and not limiting algal growth rates. The hypothesis is that changes in the forms and ratios of nutrients affect community composition. These changes include increases in the proportions of NH_4 to NO_3 and of nitrogen to phosphorus. Increasing ratios (more N, less P and more NH_4 in relation to NO_3) reduces the competitive advantage of larger, fast growing algal forms, like diatoms, and selects for smaller, slower growing groups like flagellates, greens and cyanobacteria (Table 1). The latter algal forms are believed to be of a lower nutritional value for herbivores like zooplankton.

Charge to Science Work Group

The charge to the Science Work Group is to evaluate the published and ongoing research in the Delta and elsewhere for each set of hypotheses in Table 1 and determine, in the best professional judgment of the group, which hypotheses are supported by the research, which are not supported, and which require additional study before they may either be accepted or refuted. The Science Work Group is also charged with preparing a prioritized list of recommendations for future research based on these discussions. The research should focus on evaluating unresolved questions that arise in the group discussions. A summary of the literature, the deliberation process, the conclusions, and the recommendations for future research will form the core of the Concentration, Forms and Ratios white paper which will be drafted by Regional Board staff. The prioritized list of recommendations for future research will be extracted from the white paper and included in the Nutrient Research Plan. The White Paper and Research Plan are intended to provide the rationale and roadmap for future research to resolve outstanding issues about whether the Ammonia Paradox and Ecological Stoichiometry hypotheses are supported in the Delta.

Work Group Process

The work group process is designed to produce an organized and transparent record of deliberations, conclusions, and recommendations for Regional Water Board staff to use in developing a Nutrient Research Plan. The process includes a minimum of three work group meetings.

The first work group meeting is planned as an organizational session with seven main objectives:

- Ensure that all members understand the charge, the amount of commitment involved and the nature of work products.
- Review and solicit input from members on whether the hypotheses listed in Table 1 have been correctly stated or whether they should be revised or augmented.

- Determine whether the proposed membership of the work group (Table 2) needs additional expertise to produce a robust product.
- Determine whether the work group process is economical in terms of members' time but will still achieve the desired outcome.
- Determine whether Table 3 is an inclusive list of all research groups evaluating important nutrient hypotheses related to aquatic food web effects in the Delta who should be invited to present their findings.
- Formulate a series of questions for each presenter to address as part of their presentations, as illustrated by the draft questions in Table 4
- Identify dates for subsequent work group meetings.

The second session would evaluate the evidence for and against the NH₄ paradox. A number of research groups have been evaluating these hypotheses from different perspectives (Table 3). Each would be invited to address the group and summarize the published literature and how their findings support or refute it. Each presenter will also be asked to answer specific questions (Table 4) previously forwarded to them by the work group and by the other presenters. These questions will be designed to elucidate the likely sources of differences in study results and further the work group's goal of identifying additional needed research. Presenters will also be asked to submit in PDF format a week before the meeting all papers that they intend to cite during their presentation. This library will be uploaded to the Regional Board web site and made available for all to review before the meeting. After each presentation the Science Work Group, other presenters, and STAG members may question the presenter.

The Science Work Group would then meet to review and discuss their findings and determine additional research needed to meet the work group charge of accepting or refuting the hypotheses in Table 2. Board staff will summarize the discussion and conclusions of the work group and make them available to the work group to ensure their accuracy. The summary of the presentations, discussion, conclusions and recommendations for future research would form the key elements of the draft white paper to be prepared by Regional Water Board staff.

A third session of the Science Work group will evaluate hypotheses concerning Ecological Stoichiometry. The details of how this session will be conducted are not included here as it will be organized after the Ammonia Paradox session and will benefit from lessons learned in those meetings.

Products of the work group process will include:

- Science Work Group white paper and prioritized research recommendations.
- STAG comments and recommendations.

- State Board Independent Science Panel comments and recommendations
- Final white paper and research plan after comments from the State Board Independent Science Panel and STAG have been received and addressed.

This package is intended to support the transparency of the process and ensure that Regional Water Board staff and other interested parties have a complete suite of information needed for their consideration and decision making.

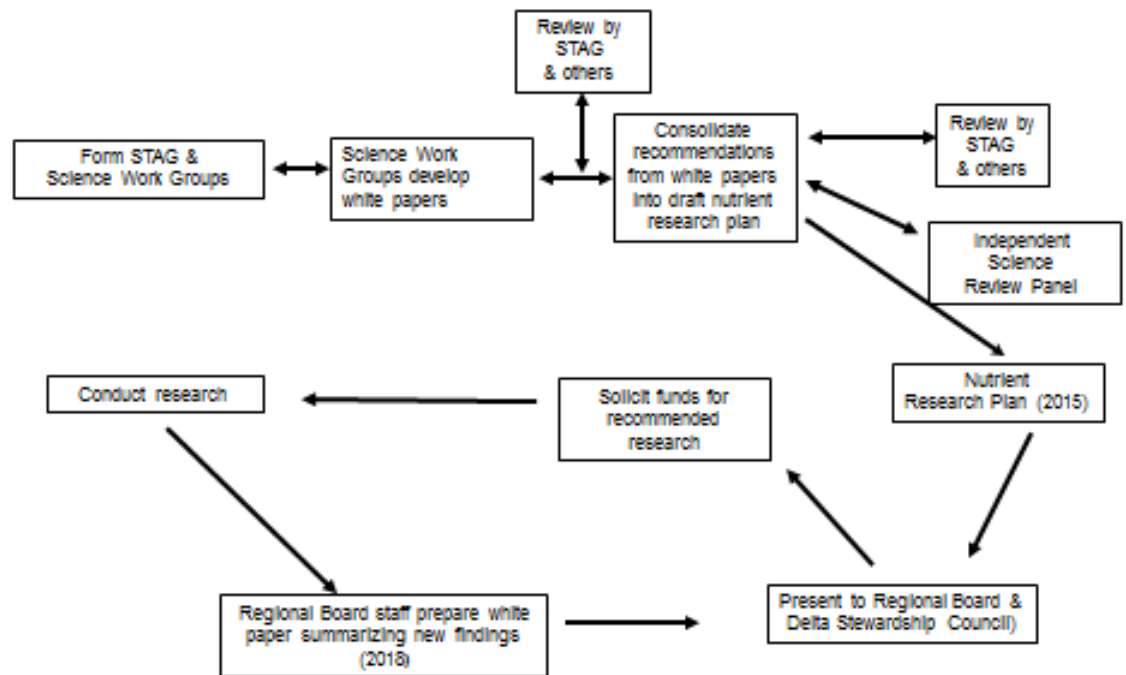


Figure 1 Tasks and schedule for developing and implementing the Nutrient Research Plan as outlined in the 2014 Delta Strategic Work Plan. Water Board staff will solicit input at a 2018 Regional Water Board Meeting whether nutrient objectives are needed in the Delta and whether staff should begin their development.

Table 1. Hypotheses for evaluation by the Concentrations, Forms and Ratios Science Work Group.

Ammonia Paradox Hypotheses	
1	Ho: Elevated NH ₄ levels reduce NO ₃ uptake by both diatoms and by the phytoplankton community present in the Delta.
2	Ho: The rate of total N uptake by both diatoms and by the phytoplankton community present in the Delta is greater at low than at high NH ₄ concentrations.
3	Ho: Diatom and phytoplankton community primary production rates in the delta decrease with increasing NH ₄ concentrations.
4	Ho: Elevated NH ₄ results in a shift in algal species composition in the Delta by selecting against species with a lower N uptake rate and a slower growth rate at high NH ₄ levels.
Ecological Stoichiometry Hypotheses	
1	Ho: Changes in ambient N:P ratios cause shifts in algal species community composition in the Delta.
2	Ho: Changes in ambient N:P ratios decrease the food quality of the algal community present in the Delta for herbivores like zooplankton.

Table 2. Concentrations, Forms and Ratios Science Work Group members.

Individual	Agency	Work Group
David Senn	San Francisco Estuary Institute	X
Lisa Thompson	Sac Regional County Sanitation District	X
Tim Mussen	Sac Regional County Sanitation District	X
Stephanie Fong	State and Federal Contractors Water Authority	X
Frances Brewster	Santa Clara Valley Water District	X
Peggy Lehman	Department of Water Resources	X
Randy Dahlgren	U.C. Davis	X
Richard Connon	U.C. Davis	X
Erwin Van Nieuwenhuyse	U.S. Bureau of Reclamation	X

Key: X = Individual agreed to participate in work group.

Table 3. Potential presenters for evaluating the NH₄ Paradox hypothesis.

Individual	Agency/Institution	Research Area of Interest	Participation
Jeff Miller	AquaScience	Laboratory NH ₄ algal dosing experiments	?
Pat Glibbert	U. Maryland	Laboratory/mesocosm/field experiments with nutrients and algae	X
Dick Dugdale/Frances Wilkerson	Romberg Tiburon Center	Field N uptake experiments	?
Mine Berg	Applied Marine Sciences	Laboratory NH ₄ algal dosing experiments	X
Tamara Kraus	U.S. Geological Survey	Sacramento River Lagrangian study	?
Alex Parker	California Maritime Academy	Mesocosm/Field Experiments	X
Richard Connon	U.C. Davis	NH ₄ Paradox Review paper	X

Key: X = Individual has agreed to participate in the work group. ? = Individual has been identified as a potential candidate but has not yet been contacted.

Table 4. Potential categories of questions for presenters to address in their presentations, if consistent with their research interests

	Questions
1	Are there genetic or physiological differences between NH ₄ tolerant and sensitive algal species? Do these results come from one or from multiple laboratories?
2	Do laboratory experiments with laboratory water and pure algal cultures show differential N uptake by NH ₄ sensitive and NH ₄ tolerant species as a function of increasing NH ₄ levels? Do these experiments result in the accumulation of higher biomass by NH ₄ sensitive species at lower NH ₄ levels? Are these results from one or from multiple labs?
3	Do laboratory and/or mesocosm experiments with delta water and/or the local phytoplankton community show an increase in biomass and a shift in algal species composition consistent with predictions for NH ₄ tolerant and NH ₄ sensitive species?
4	Are the results of whole ecosystem amendment experiments consistent with laboratory results? Are there one or multiple whole ecosystem experiments?